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VINEYARD PLANS

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A plan for a vineyard in the broad sense of the term should take into consideration the capital, experience, and skill of the owner, as well as the climatic, soil, and water conditions of the location. It should cover every operation from the preparation of the land and the choice of planting stock to the management of the fully established vineyard. In the narrower and more usual sense in which it is used here, it means the charting of the position of vines, roads, irrigation systems, permanent windbreaks, and enclosures.

In making a plan we must decide on the number of vines per acre (density) and their relation to each other and to the points of the compass (arrangement).

Density.—The more vines we plant to the acre the greater the cost of planting, staking, pruning, cultivation, harvesting, and other vineyard operations, and the smaller the possible development of the individual vines. The fewer vines to the acre, within certain limits, on the other hand, the smaller the cost of these operations and the greater the possible development of each vine. Within very wide limits, the amount of crop of a mature vineyard is independent of the density of planting. The fewer vines to the acre, the larger each vine will grow and the larger crop it will produce. Ten small vines produce no more than one large vine occupying the same area.

It is to the interest of the grower, therefore, to decrease the density of his planting until he reaches a limit determined by the possibilities of development of the individual vine and by the cost of supporting very large vines with stakes or trellises.

The size to which a vine will grow depends on the nature of the variety, the climate, the available water, and the depth and fertility of the soil. Some vines, like the Raisin Muscat and the Zinfandel, cannot be made to grow very large, however favorable the conditions. If planted too sparsely, therefore, the crops of the vineyard will be permanently small. Other vines, like Mission, Emperor, Sultanina, and most of our common table grapes, have great possibilities of

growth. The first crop of the vineyard, if such vigorous vines are crowded, may be larger, but subsequent crops will be smaller and the running expenses greater. The range of density usual in California is about from 300 to the acre for vigorous varieties in fertile soil, in warm districts, to 650 for small-growing varieties and shallow soil, especially in the cooler districts.

Under exceptional conditions other considerations apply. In cold, wet regions, dense planting is advisable as it promotes shallow rooting and early ripening. In northern Europe as many as 20,000 vines are sometimes planted on an acre. If moisture is deficient, a few vines may give good crops where a large number on the same area would

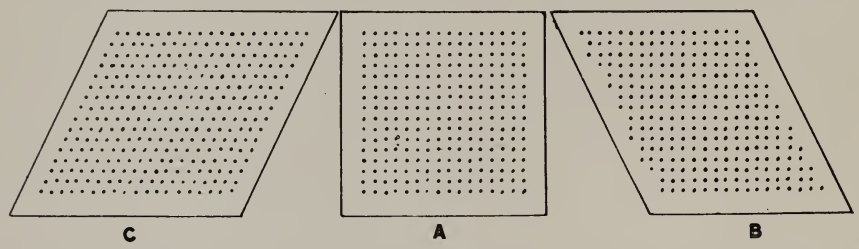

Fig. 1.—A. Rectangular piece of land laid out in squares.—B. Rhomboidal piece of land laid out in squares.—C. Rhomboidal piece of land laid out with rows parallel to the boundaries.

fail. Such situations should not be chosen for vines in California while there are immense areas available where the conditions are more favorable. A few varieties of table grapes, such as Ohanez and Zabalkanski, produce little unless the vine is given a very large development. In Almeria the Ohanez is grown on overhead trellises with less than 200 to the acre.

Arrangement.—For all varieties which will bear maximum crops when the vine is trained to the form of a low bush and pruned to short spurs, the arrangement of the vines in squares is usually preferred. This allows of cross-cultivation with the same implements and requires little hand work in hoeing. This is called the *Square System* (see fig. 1).

The only other arrangement of practical interest is the *Avenue System.* In this system the vines are arranged in more or less elongated rectangles, that is, in rows which are further apart than the distance between the vines in the rows (see fig. 2). This usually allows of cultivation in only one direction and should be adopted only when it is certain that the benefits are sufficient to counterbalance this objection. The objection is serious only in land badly infested with such weeds as Johnson or Bermuda grass.

The principal cases where the avenue system is advisable are:

(*a*) For varieties which require cane pruning and which, therefore do best when trellised;

(*b*) For varieties which require a very long trunk and therefore do best with the horizontal cordon method of pruning;

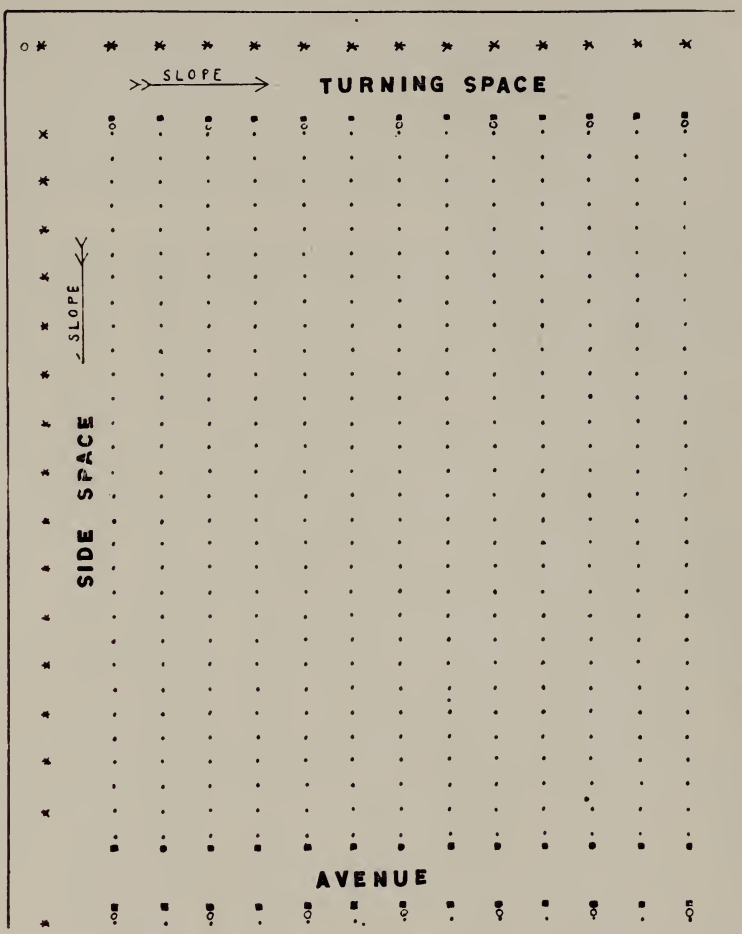

Fig. 2.—Example of a vineyard plan. Avenue system specifications.

. = vine; * = border tree; o = water outlet; ■ = trellis post.

Method of pruning	Cane
Vine distance	7 ft. × 14 ft.
Width of blocks	203 ft. = 30 vines.
Width of avenues	23 ft.
Width of turning spaces	30 ft. (including 10 ft. for border trees).
Width of side spaces	20 ft. (including 10 ft. for border trees).

(*c*) For raisin grapes where it is advantageous to have wide spaces between the vines in which to dry the grapes.

The avenue system, when the rows are at least 12 feet apart, facilitates the hauling of grapes, boxes, manure and other materials in all parts of the vineyard and is convenient for tractor cultivation and power spraying. It necessitates less handling and carrying of table grapes, thus preserving their keeping and shipping qualities. It is suited to furrow irrigation and to the growing of cover crops. It makes it possible to irrigate and cultivate later in the summer without injury to the growing shoots and to defer the plowing-in of cover crops until late in the spring, thus obtaining the benefit of a larger bulk of green manure. For these reasons it is preferred by some growers for all cases.

The distances and arrangements which seem most adapted to the usual conditions of vine growing in California are shown in the following table.

TABLE 1

VINEYARD PLANTING PLANS

System			Width of Blocks		Spaces in Feet		
1	2	3	4	5	6	7	8
Pruning	Distance	Density	Feet	Vines	Avenues	Turn. Sp.	Side Sp.
Head	8 × 8	642	248	32	16	16	16
Head	8 × 8	636	200	26	16	16	16
Head	9 × 9	504	243	28	18	16	16
Head	9 × 9	501	207	24	18	16	16
Head	10 × 10	406	250	26	20	16	16
Head	10 × 10	403	200	21	20	16	16
Head	6 × 12	565	246	42	18	16	10
Head	6 × 12	561	204	35	18	16	10
Head	8 × 12	431	248	32	16	16	10
Head	8 × 12	428	200	26	16	16	10
Cane	6 × 12	557	246	42	22	19	10
Cane	6 × 12	550	204	35	22	19	10
Cane	7 × 14	407	245	36	23	20	10
Cane	7 × 14	401	203	30	23	20	10
Cordon	7 × 14	406	245	36	24	17–24	10
Cordon	7 × 14	399	203	30	24	17–24	10
Cordon	8 × 16	313	248	32	25	17–25	10
Cordon	8 × 16	309	200	26	25	17–25	10

This table gives some suitable planting plans for a square 40 acre vineyard. It is intended to aid in deciding the various operations which should be considered in laying out a vineyard before a vine

is planted. Each column represents a factor of the problem which must be settled in agreement with the other factors if inconvenience and costly mistakes are to be avoided.

Column 1. The *system* of pruning must be decided on first, as this will determine the arrangement of the vines, the proper width of avenues and turning spaces, and whether the square or avenue system should be adopted.

Column 2. The distances between vines and between rows (arrangement) are governed by the considerations already discussed. The examples given are all used in California and are sufficient for practically all conditions here. The wider distances alone are suitable for tractor cultivation; anything below 9 feet is inconvenient even for horse work.

Column 3. The number of vines to the acre (density) must be known in order to be able to calculate the number of vines necessary for planting. The number given is less than the theoretical number obtained by dividing the number of square feet in an acre by the number of square feet occupied by a vine. The difference is due to the land needed for avenues, turning spaces and border spaces. It varies from 5 to 8 per cent less than the theoretical number, with head pruning, and from 6 to 10 per cent, with trellised vines.

Columns 4 and 5. The vineyard should be divided into *blocks* separated by avenues for convenience in working and especially in harvesting. Experience shows that blocks of from 200 to 250 feet are the most suitable. Much greater distances necessitate expensive and laborious carrying and hauling. In irrigating vineyards, furrows about 250 feet long usually give the best results, and where longer furrows are more economical they can cross two or more blocks. Large blocks are especially troublesome in trellised vineyards. It is a great convenience in keeping records and in other ways to have all the blocks of the same size.

Column 6. The spaces or *avenues* between the blocks must be wide enough to allow the passage of wagons without injury to the vines in full growth. The minimum space is about sixteen feet, but for very large and vigorous vines two or three feet more is better.

In laying out a cane-pruned vineyard it is necessary to leave, in addition to this wagon space, a sufficient space for fruit canes between the end vine and the trellis post. This space will be about half the distance between the vines or a little more, added to each side of the avenue. For example, if the vines are 7 feet apart the avenue should be 16 + 7 or + 8, 23 or 24 feet wide.

With cordon-pruned vines, a similar allowance should be made, though in this case the extra distance is all on one side of the avenue.

Column 7. Wherever the wagons, teams or cultivating implements have to turn, a sufficient *turning space* must be left. For this purpose at least 16 feet is needed. For head-pruned vines planted on the square system, a turning space is needed on all sides of the vineyard. For trellised vines which can be cultivated only one way, a turning space is usually needed only on two sides.

With cane-pruned vines an addition of about half the distance between the vines must be left for the trellis post and fruit canes. For example, if the vines are 6 feet apart the turning space should be about 16 + 3 or 4, 19 or 20 feet wide (see fig 2).

With cordon-pruned vines, an addition equal to or a little greater than the distance between the vines is left at the side toward which the cordons run. For example, if the vines are 7 feet apart and the cordons run from north to south, the turning row at the south end should be about 16 + 8, or 24 feet.

Column 8. Where cultivation takes place only in one direction there is usually no need for turning spaces on two of the sides. Here a *side space* should be left for cultivation. This space should be wide enough for cultivation, usually about ten feet.

Whatever the size of the vineyard, it is usually impossible to choose the various widths of blocks and spaces so that they will conform exactly to the conditions given and still utilize all the land. There will usually be a few feet to spare or lacking in one or both directions, however carefully we plan. If the excess is small, it can often be utilized by adding to the width of the turning space or by widening a central avenue. If large, it is often needed for border trees or irrigation ditches. If not needed for any such purpose, it should be utilized by making one block a little wider than the rest. When there is a deficiency, one block should be reduced in width.

The number of vines to an acre given in column 3 has been calculated for the case where the extra or deficient space has been utilized to widen or contract one block.

It is possible by the use of a simple formula to calculate the number of vines needed for any rectangular piece of land with any arrangement and any width of unplanted spaces.

TABLE 2

CALCULATION OF NUMBER OF VINES NEEDED

Data	Examples 1	2
L = length of land in feet	1320	2000
W = width of land in feet	1320	1000
A = width of avenues	23	18
T = width of turning spaces	20	16
S = width of side spaces	10	10
F = feet between vines	7	6
Q = feet between rows	14	12
V = number of vines in row	30	35

CALCULATIONS

R = rows in a block = $\frac{W-2S}{Q}+1$	93	82
B = number of blocks = $\frac{L-2T+A}{F(V-1)+A}$	5.77	8.95
G = acres of land = LW ÷ 43560	40	45.91
N = vines in whole piece = V R B.		
D = vines to the acre = N ÷ G	402	560

In example 1, the calculation is as follows:

$R = \{(1320—20) \div 14\} + 1 = 93$ rows—2 ft., or 92 rows + 12 ft.

The number of rows in a block can be 93 if the side spaces are reduced to 9 feet, or 92 if they are increased to 16 ft.

$B = (1320—40 + 23) \div 7\ (30\text{-}1) + 23 = 5.77$ blocks.

There will therefore be 5 blocks 30 vines wide and one block 22 vines wide with 3 feet to spare.

$G = (1320' \times 1320') \div 43560 = 40$ acres.

$N = 30 \times 93 \times 5.77 = 16098$ vines in the piece.

$D = 16098 \div 40 = 402 =$ Numbers of vines to the acre.

By having only 92 rows to a block the number of vines would be decreased to 15,925 or by having 36 vines in a row and only 5 blocks it would be increased to 16,278.

In the same way the number of vines for the whole piece and the "density" or number of vines to an acre can be calculated for example 2 or for any other set of conditions.

When land is left for roads, border trees or irrigation ditches, these spaces are added to the avenues, turning spaces or side spaces, as the case may be, when computing the averages A, T, and S.

The number given per acre in Table 1 is based on a convenient arrangement for a square 40 acre piece of land. The number per

acre will usually be a little less than that given, owing to the space occupied by irrigation ditches, border trees, windbreaks and buildings.

Direction of rows.—In deciding on the direction of the rows we must consider convenience of irrigation, cultivation, and hauling, economy of spacing, and the effects of the wind and sun on the vine and its crop.

Where the square system is used, it is simply a question of convenience and economy of spacing. If the land is a regular rectangle it is most convenient to run the rows parallel to the boundaries (see fig. 1A). If it is regular but slightly diamond shaped, that is, with corners which are not exact right angles, the same method is also advisable as it avoids inconvenient short rows and irregular blocks and turning spaces (see fig. 1C).

This system makes the rows of vines oblique and the width between rows is narrowed. In figure 1C, the angle is 64° and the cultivation space is decreased from 10 feet to 9 feet. By increasing the distance between the vines to 10 ft. 11 in. the cultivation space would still be 10 ft. When the angle reaches 60° the arrangement of the vines will be in equilateral triangles and there will be cultivation spaces 8 ft. 9.6 in. in three directions. When the angle is less than 60° the rectangular method shown in figure 1B is most convenient.

If the piece of land is irregular it is best to use a main road, or a long straight side, if there is one, as a base line and lay out the rows and blocks at right angles to it. In default of this, a base line can be run along the longest axis.

When the avenue system is used, the direction of the rows requires careful consideration (see figures 2 and 4).

Where irrigation is practiced, it is the deciding factor. If the water can be run in only one direction this is the direction in which the rows must go. It is often possible, however, to choose between two or more directions of irrigation and to grade the land accordingly. Where the land is nearly level and the irrigation furrows short, this is usually possible without great expense. In such cases other considerations apply.

An important factor of choice is the direction of the prevailing winds, especially if these are fairly strong. In such cases the rows should run as nearly as possible in the direction of these winds, particularly if the vines are to be trellised. This diminishes the amount of damage from broken shoots in the spring and keeps the leafy shoots where they shade the crop during the summer. It also tends to keep the growth of the vines in the row instead of spreading out where they would be injured in cultivation.

Another important factor is the influence of the direct rays of the sun on the ripening and quality of the grapes. In the cooler regions the direction north to south is most favorable from this point of view. When trellised vines are growing in this direction, the grapes are exposed to the direct rays of the sun in the early morning and the late afternoon and shaded in the middle of the day. This tends to ripen them early by increasing the amount of heat to which they are subjected and to improve their quality by equalizing the temperature during the day.

In the hotter regions a west to east direction is often more favorable because it tends to shade the grapes from the sun during the hottest part of the day, the early afternoon. The hot sun from 2 to 4 p. m. is a frequent cause of sunburn, especially in regions where west winds are severe.

For cordon vines a north to south direction has the advantage of exposing the bare trunk less to the direct rays of the sun, especially during the first three or four years when the cordons are incomplete.

In vineyards where the grapes are dried, an east to west direction of the rows has the advantage of making it possible to expose the trays more completely and for a longer part of the day to the sun. This is of most importance in the colder regions and with late grapes.

It is seldom possible to give the rows the most favorable direction from all these points of view; in each case the best possible compromise should be made.

In most cases in the coast valleys the direction north to south is best in locations protected from strong west winds. In the hotter interior the direction west to east is usually preferrable, except for cordons where a north to south direction is to be preferred wherever the west winds are not too strong. Cordons should never be used except with very vigorous varieties and in rich well-watered soil, and in these cases the danger of sunburn from the afternoon sun is not great.

Where the land is very irregular, as in a hilly country, no special rule can be applied to the whole vineyard. Each piece must be considered as a special case and the method of laying out determined by its special circumstances without reference to the other pieces.

Contour planting.—For rolling or hilly land where grading for cultivation or irrigation in straight rows is impracticable it is often advisable to plant the vines in rows determined by the contour lines. An example of how this can be done is given in figure 3, representing a small contour vineyard laid out by the Irrigation Division of the Branch of the College of Agriculture at Davis.

The westerly part of the land in figure 3 is a hillside with an easterly slope of about seven feet in a hundred, which is too steep for irrigation down the main slope. The easterly or lower part has a gentle northerly slope which is just about right for irrigation.

The grade on which vines should be set when using the contour system depends upon the soil, being much flatter with heavy soils, to permit the irrigation water to soak well into the ground, than on sandy soils, although on sandy soils care should be taken to keep the grades of the furrows low enough to avoid erosion.

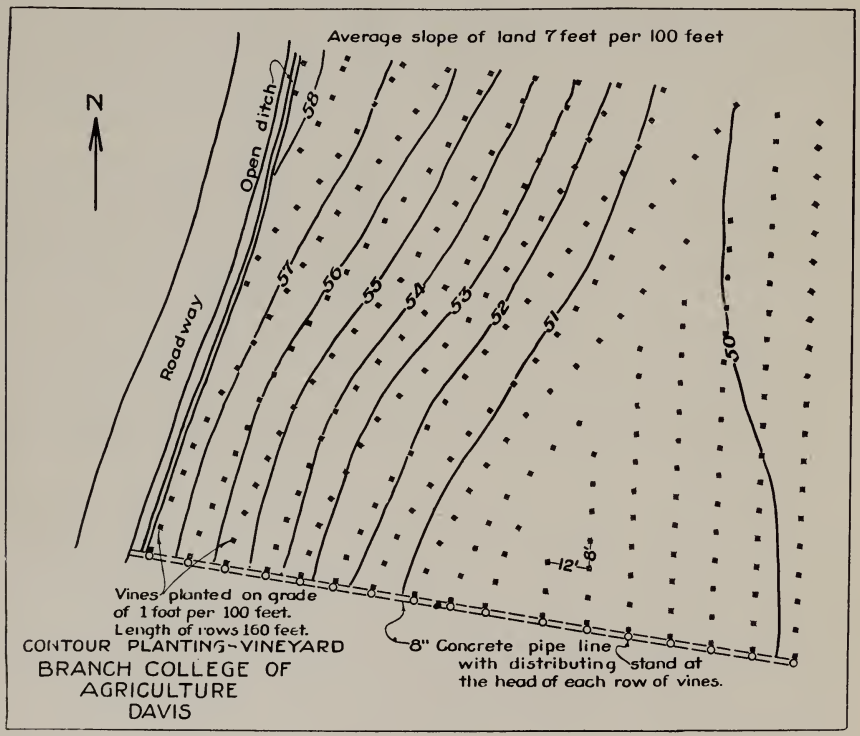

Fig. 3.—Contour planting for a vineyard.

The vines at Davis (see fig. 3) are planted 8 feet apart in the rows and the rows are started 12 feet apart. If the slope is approximately even, the rows continue about 12 feet apart. As the slope varies, however, the spacing between the rows becomes more or less than 12 feet. When the land is so steep that a row comes too close to the last the practice is to end this row and start a new one.

Irrigation systems.—A vineyard plan should include the location of the canals, ditches, pipes and outlets of the irrigation system. The furrow system is generally recognized as the most suitable and for the

even irrigation of all the vines the furrows should in most cases be from 200 to 250 feet long. This has already been shown to be the most convenient width for blocks. There should therefore, be a supply line, permanent or temporary, along the upper side of each block.

If open ditches are used there should be a permanent ditch running along one side at the ends of the blocks and from this a temporary ditch along the upper side of each block. Where an underground pipe system is installed there should be an outlet at every second or fourth row near the first vine along the upper side of each block. An outlet at every second vine though more expensive to install saves a considerable amount of expense for hand work in irrigation.

The water outlet should be in line with the row of vines and 2 to 4 feet beyond the first vine. In a trellised cane-pruned vineyard the most convenient position for this outlet is between the first vine and the trellis post (see fig. 2). In this position the post protects it from being run over and the post is less likely to be loosened by an excess of water in the soil around it. When the water outlet is placed beyond the post, a brace is usually needed to keep the wire taut.

Border trees.—In many cases it is advisable to grow a row of trees along one or more sides of the vineyard or parts of it. The principal use of these trees is to serve as permanent windbreaks, and they are needed wherever there are heavy prevailing winds during the growing season.

The proper distance between the rows of windbreak trees will depend on their height and on the severity of the wind. The effect of the windbreak does not extend usually beyond one-eighth of a mile. In very windy districts it is found advisable to divide the vineyard up into 10-acre pieces each surrounded by a screen of trees. These trees require room and vines will not grow and bear well very close to them. Some trees, such as cottonwoods and eucalyptus, require a great deal of room; others, such as *Tamarix articulata* (Athol.) comparatively little. If a row is planted five feet from the outside boundary of the vineyard, five feet plus the turning row on the side of the vines is usually sufficient space. Rows through the middle of the vineyard can be accommodated by doubling the width of the avenues where they occur.

Windbreaks planted in this way surrounding every ten acres occupy about 10 per cent of the land, but the protection from wind may easily increase the crop more than this and much improve its quality. Windbreaks of figs or olives will also return a crop, but their rate of growth is too slow in most cases.

The amount of land taken up by the windbreaks may be diminished by having the rows of trees only in one direction or farther apart in the direction from which least wind comes. Windbreaks

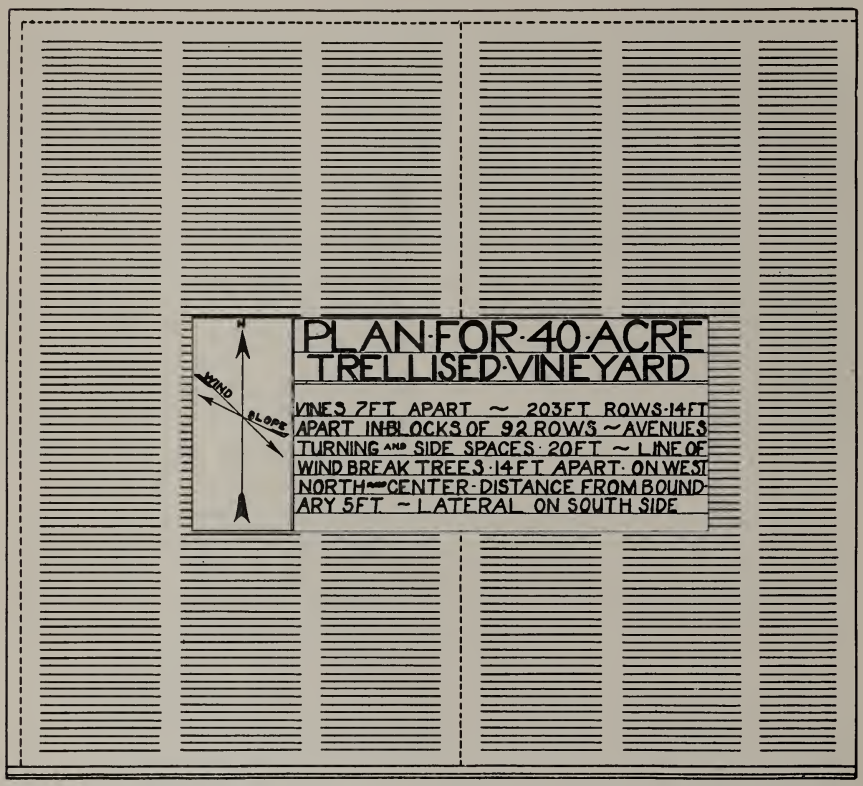

Fig. 4.—Plan of a 40-acre trellised vineyard.

running north to south every 660 feet and east to west every 1320 feet may be sufficient. The windbreaks on the east and south sides may also be omitted.

Figure 4 shows a plan for a cane-pruned or cordon vineyard with indications of the position of border (windbreak) trees, irrigation canal, and blocks with convenient spacings for rows, avenues, turning spaces and side spaces.